

Final Technical Report

for

**Conical Magnetic Bearing Development
and Magnetic Bearing Testing for
Extreme Temperature Environments**

**NASA Grant Number
NCC3-1046**

Grant Duration
March 4, 2003 to June 3, 2004

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August 2004

The main proposed research of this grant were: to design a high-temperature, conical magnetic bearing facility, to test the high-temperature, radial magnetic bearing facility to higher speeds, to investigate different backup bearing designs and materials, to retrofit the high-temperature test facility with a magnetic thrust bearing, to evaluate test bearings at various conditions, and test several lubricants using a spiral orbit tribometer.

A high-temperature, conical magnetic bearing facility, shown in Figure 1, has been fully developed using *Solidworks*. The facility can reuse many of the parts of the current high-temperature, radial magnetic bearing, helping to reduce overall build costs. The facility has the ability to measure bearing force capacity in the X, Y, and Z directions through a novel bearing mounting design (Figure 2). The high temperature coils and laminations, a main component of the facility, are based upon the current radial design and can be fabricated at Texas A&M University. The coil design was highly successful in the radial magnetic bearing. Vendors were contacted about fabrication of the high temperature lamination stack. Stress analysis was done on the laminations. Some of the components were procured, but due to budget cuts, the facility build up was stopped.

The high temperature radial magnetic bearing was modified with a high speed coupling and was operated to 30,000 RPM and 1,000°F. The target speed of 36,000 RPM was not obtained because the coupling failed during testing and money was not available for a replacement. The facility was first operated to 25,000 RPM and 1,000°F with ball bearings as the support/backup bearings. This was the limit with these bearings due to heating during operation. In order to operate the rig to higher speeds and also to investigate more compliant backup bearings, hydrostatic bearings were designed and installed. The bearings were made from a novel, high lubricity material to study touchdown events. The facility was operated to 30,000 RPM and 1,000°F with this configuration. Touchdown testing was in progress, but was stopped due to a lack of funds.

The third objective, to install a high-temperature thrust bearing, was postponed. This bearing had delayed delivery and arrived at the end of this grant. The facility was initially installed, however full sensor build up, data acquisition programming, and testing was not completed.

The fourth objective of qualifying new and used bearings as a function of temperature and comparing results to theoretical models was completed. Torque and resistance data was taken for several bearings as a function of speed and temperature. From this information, lubrication regime transitions could be monitored and compared to a theoretical model that predicts such changes. Good correlation between the model and the experimental results existed; verifying both the model and the measurements. Several lubricants were tested using the spiral orbit tribometer (SOT). Testing compared lubricants for differences in lubricated life in the boundary lubrication regime. Vapor pressure tests on these lubricants were also performed. All the results were summarized and presented to NASA in a memo or report format.

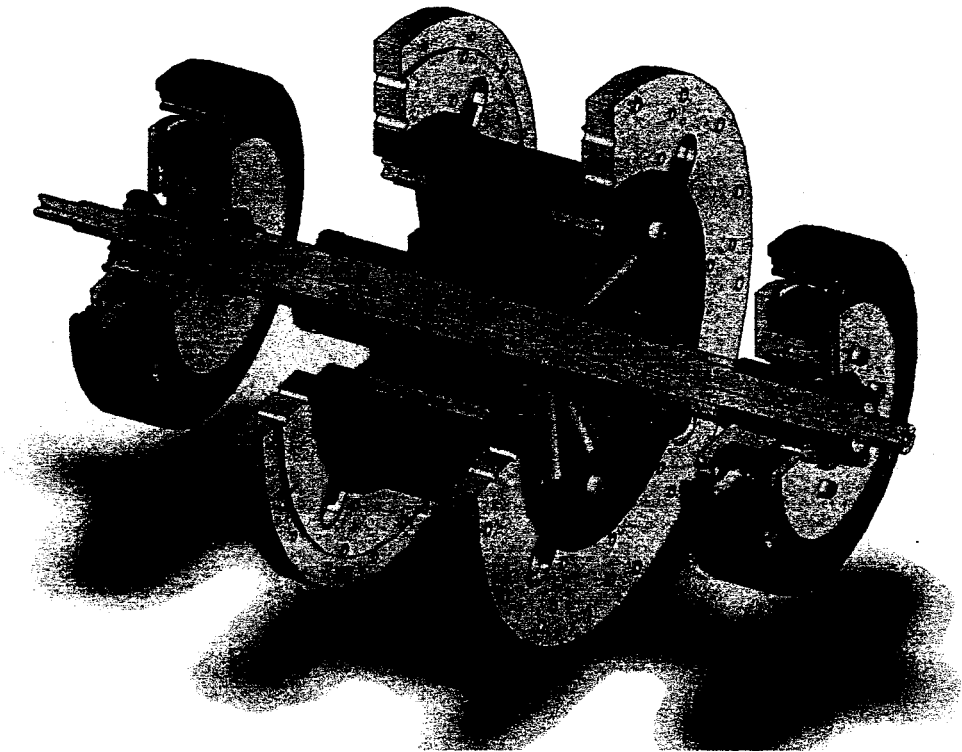


Figure 1 – High-temperature, conical magnetic bearing

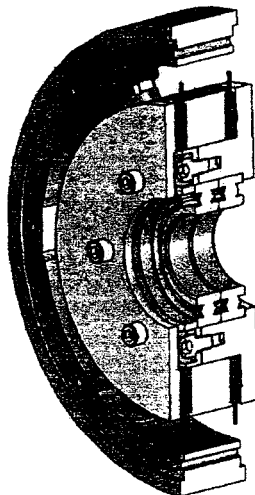


Figure 2 – Ball bearing support